Numerical tool for tsunami risk assessment in the southern coast of the Dominican Republic

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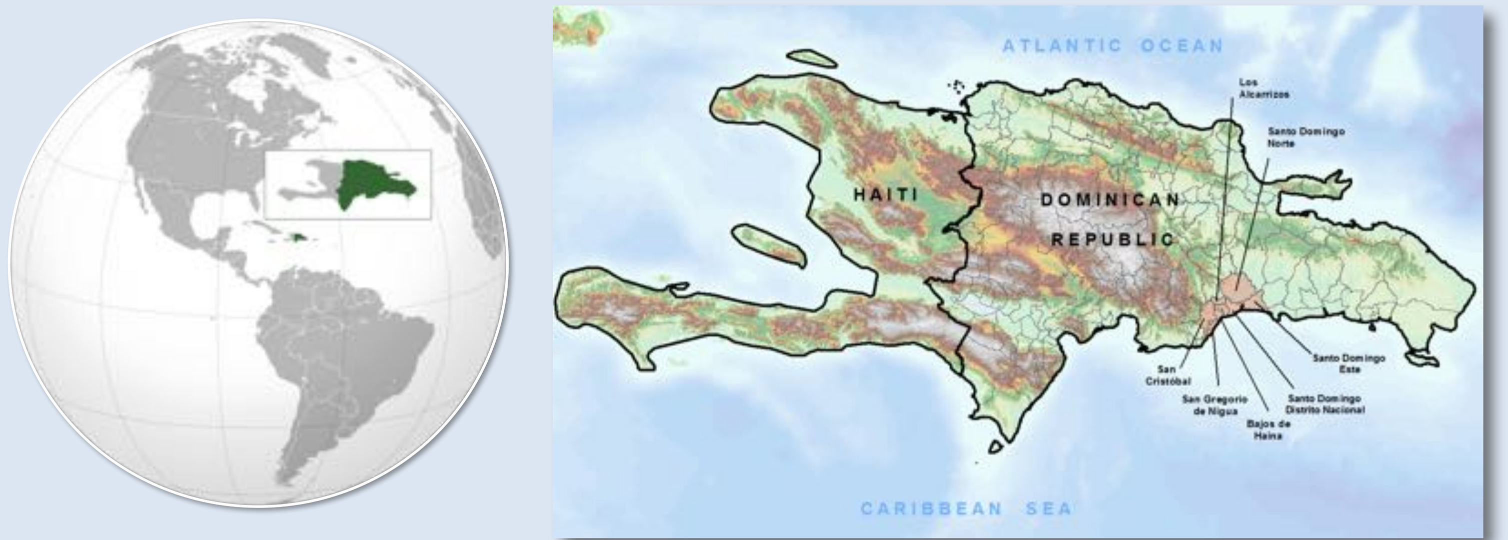
Why, where

The southern coast of Dominican Republic is a highly populated region, with several important cities including the capital, Santo Domingo. Important activities are rooted in the southern coast, such as tourism, industry, commercial ports, and energy facilities, among others. According to historical reports, it has been impacted by big earthquakes accompanied by tsunamis as in Azua in 1751 and recently Pedernales in 2010, but their sources are not clearly identified.



Aim

The aim of the present work is to develop a numerical tool to simulate the impact in the southern coast of the Dominican Republic of tsunamis generated in the Caribbean Sea. This tool, based on the Tsunami-HySEA model from the EDANYA group (University of Malaga, Spain), can be used for Tsunami Early Warning Systems due the very short computing times when only propagation is accounted, however it can also be used to assess inundation impact.

Scope

A coastal stripe of 39.3km along the Great Santo Domingo, covering Distrito Nacional, San Cristóbal, Bajos de Haina, San Gregorio de Nigua, East Santo Domingo, West Santo Domingo, and Los Alcarrizos

The Tool

The *Tsunami-HySEA* model is a non-linear hydrostatic SW model implemented in CUDA, well adapted to be run in multi-GPU architectures. Model equations in Cartesian coordinates (for simplicity, as spherical coordinates are used) write as:

$$h_t+(q_x)_x+(q_y)_y = 0$$
$$(q_x)_t+(q_x^2/h + g\, h^2/2)_x+(q_x\, q_y/h)_y = ghH_x +S_x$$
$$(q_y)_t+(q_x\, q_y/h)_x+(q_y^2/h + g\, h^2/2)_y = ghH_y +S_y$$

where $h(\mathbf{x},t)$ is the water height, H(x) bathymetry, and $q(\mathbf{x},t) = (q_x(\mathbf{x},t),\ q_y(\mathbf{x},t))$ the water flow, related with the depth-integrated velocity $\mathbf{u}(\mathbf{x},t)$ by the expression $q(\mathbf{x},t) = h(\mathbf{x},t)\,\mathbf{u}(\mathbf{x},t)$.

The notation $(\ )_t$, $(\ )_x$ and $(\ )_y$ refers to the corresponding partial derivatives.

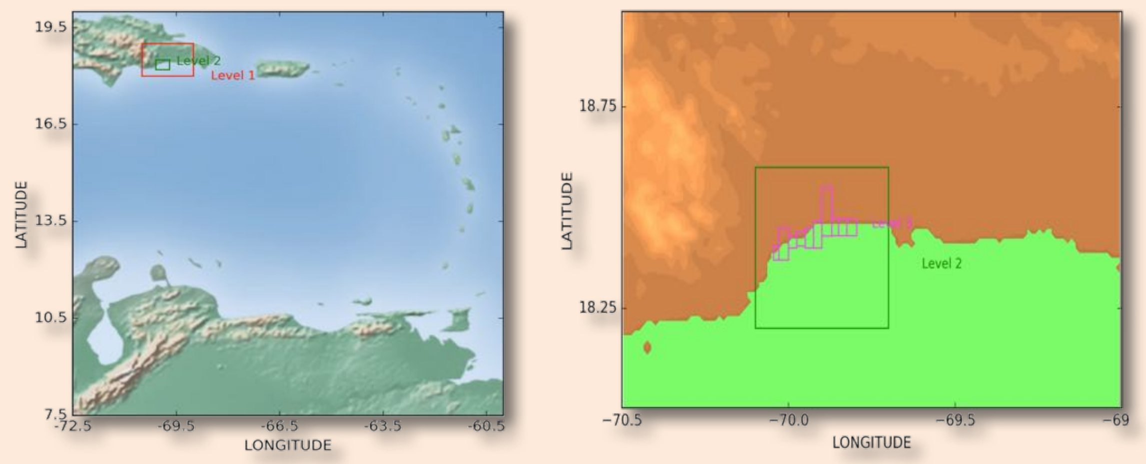
The data

Data used was obtained for the following project with the EU as the main financial actor, followed by the IGME, BRGM, CNR-IRIS, coordinated by SGN and PNUD:: "Estudio de la amenaza sísmica y vulnerabilidad física del Gran Santo Domingo" (bathymetry @2m pixel and airbone LIDAR@ .5 m resolution)

Computing domain

Global mesh: [-72.5,-60.01]x[7.49,19.99] (res. 515 m) and 3 additional submeshes:

- Level 1: [-70.5,-69.0]x[18.0,19.0] (res. 64 m)
- Level 2: [-70.1,-69.7]x[18.2,18.6] (res. 16 m)
- Level 3: 10 submeshes (res. 2 m)



Computational domain and Level 1

Level 1 (whole figure) Inside Level 2 and Level 3 composed of 10 submeshes

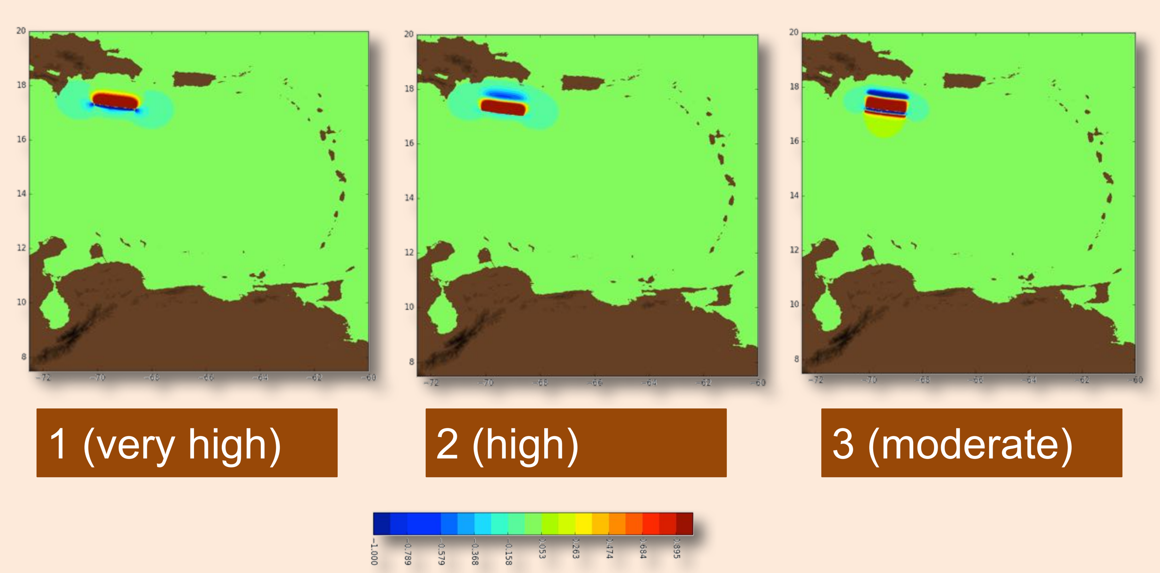
Computing times

- <1 min to compute a 2h propagation simulation with 2.4 million cells @1 arc-min resolution in 4 GPUs.
- ~1h to compute a 20min inundation simulation with 8.5 million cells @5m resolution, in 2 GPUs.
- ~18h to simulate 40 min inundation simulation with 57 million cells, @2m resolution in 4 GPUs.
- Hardware cost ~$40.000.

Testing the tool

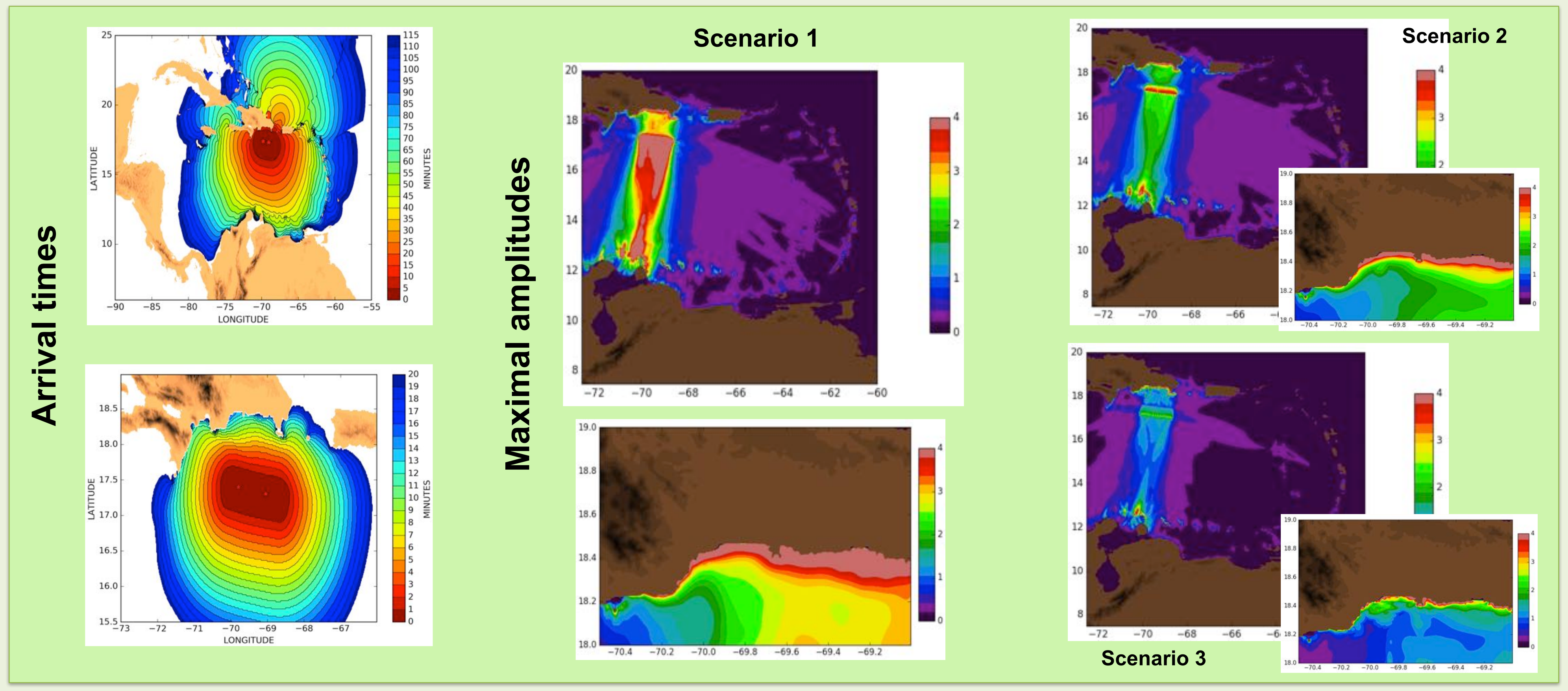
Three scenarios where used to test the numerical tool and visualization capabilities. All sources located at Muertos Trench:

1. very high expected impact;
2. high and
3. moderate impact in the area of interest.

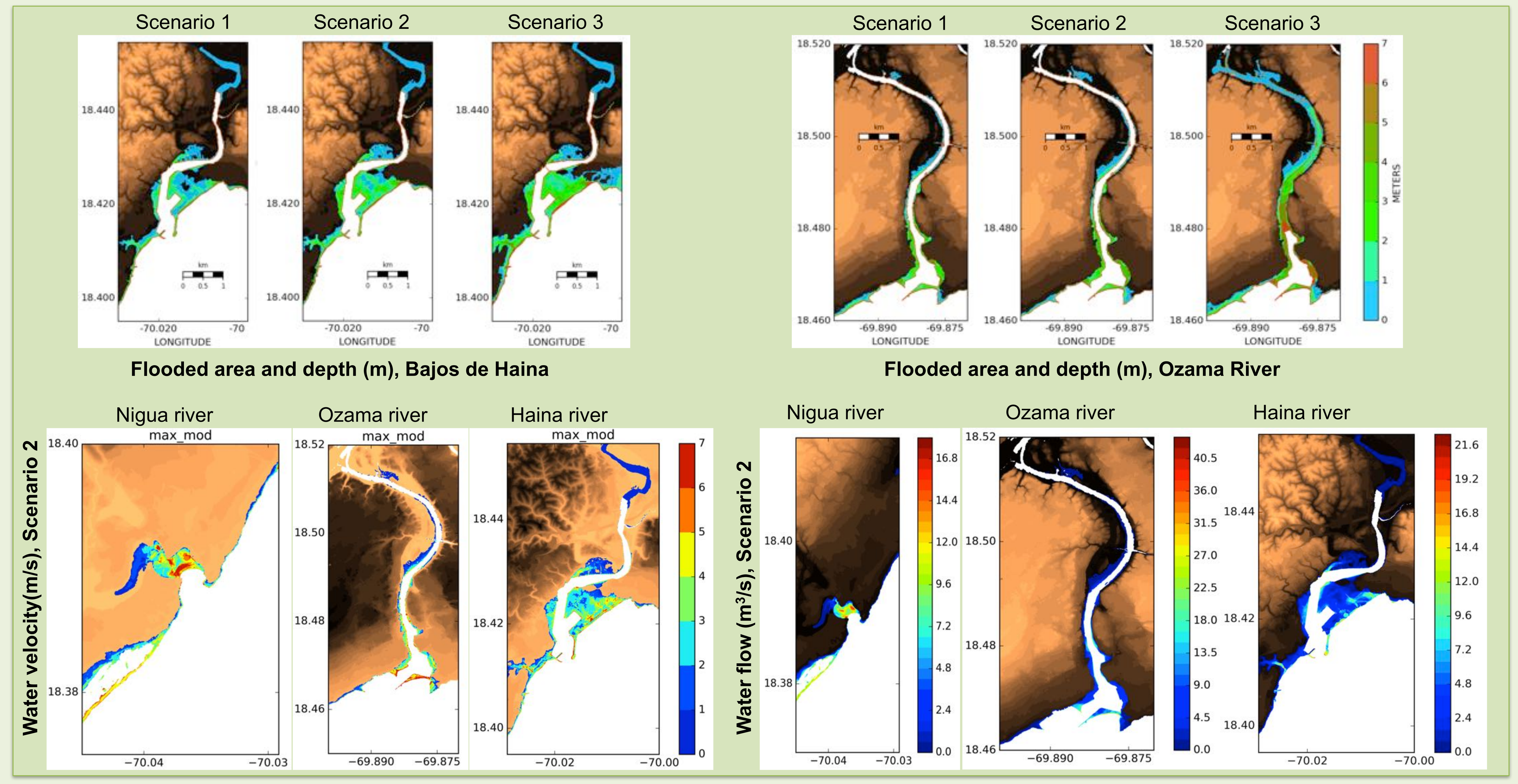


1 (very high) 2 (high) 3 (moderate)

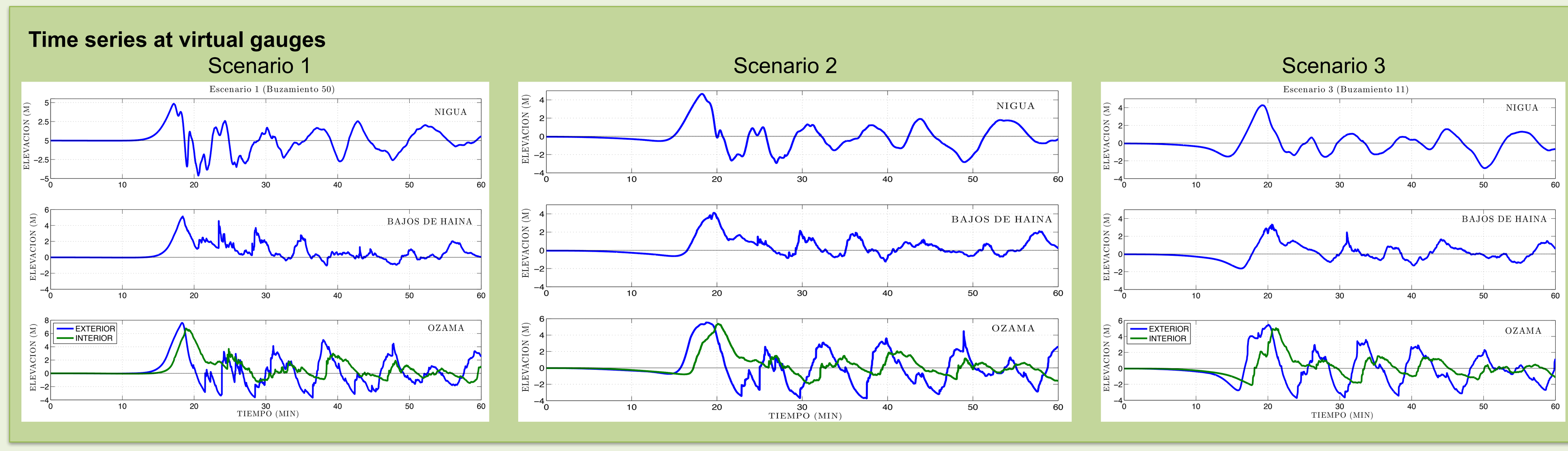
Propagation results



Flood results



Virtual buoys



Conclusions & acknowledgements

A fast, reliable and robust numerical tool has been successfully developed for the assessment of tsunami risk in the Great Santo Domingo coastal area. The model used, Tsunami-HySEA, which is implemented in CUDA to run in GPU architectures, provided very short computation times for propagation and very reasonable times for high resolution inundation simulations at a very reduced cost of the required hardware.

This research has been partially supported by the Junta de Andalucía research project TESELA (P11-RNM7069), the Spanish Government search project SIMURISK (MTM2015-70490-C02-01-R) and Universidad de Málaga, Campus de Excelencia Internacional Andalucía TECH. This research has also been partially supported by the Instituto Geológico de España throughout the coordinated project EU-PNUD-IGME-BRGM-CNR-IRS. "Estudio de la amenaza sísmica y vulnerabilidad física del Gran Santo Domingo".